



# AVERAGE VELOCITY

# SPEED

- Speed ( $v$ ) is the **distance** an object travels divided by the **time interval**.
  - Speed is a **scalar** quantity.
  - The SI unit for speed is **metres per second (m/s)**.



# VELOCITY

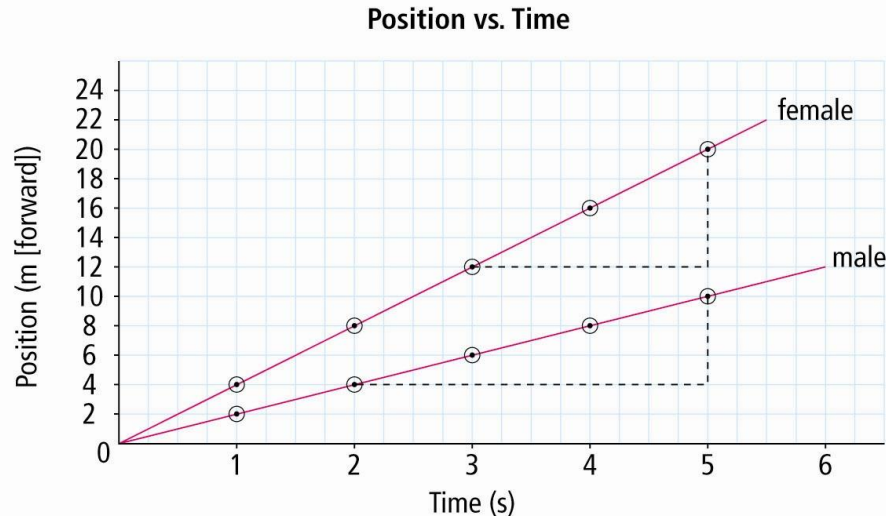
- Velocity ( $\vec{v}$ ) is the **displacement** of an object divided by the time interval.
  - Velocity describes how fast an object's **position** is changing.
- Velocity is a **vector** quantity and must include **direction**.
  - The direction of the velocity is the same as the direction of the **displacement**.
- The SI unit for velocity is **metres per second (m/s)**.



These two ski gondolas have the same speed but have different velocities since they are travelling in opposite directions.



# POSITION-TIME GRAPHS



$$\text{slope} = \frac{\Delta \vec{d}}{\Delta t}$$

- The relationship between position and time can be shown on a position-time graph.
- The slope of a graph is represented by **rise/run**.
- On a position-time graph the slope is the change in **POSITION ( $\Delta d$ )** divided by the change in **TIME ( $\Delta t$ )**.
- The **steeper** the slope the **greater** the displacement (change in position) during the time interval.



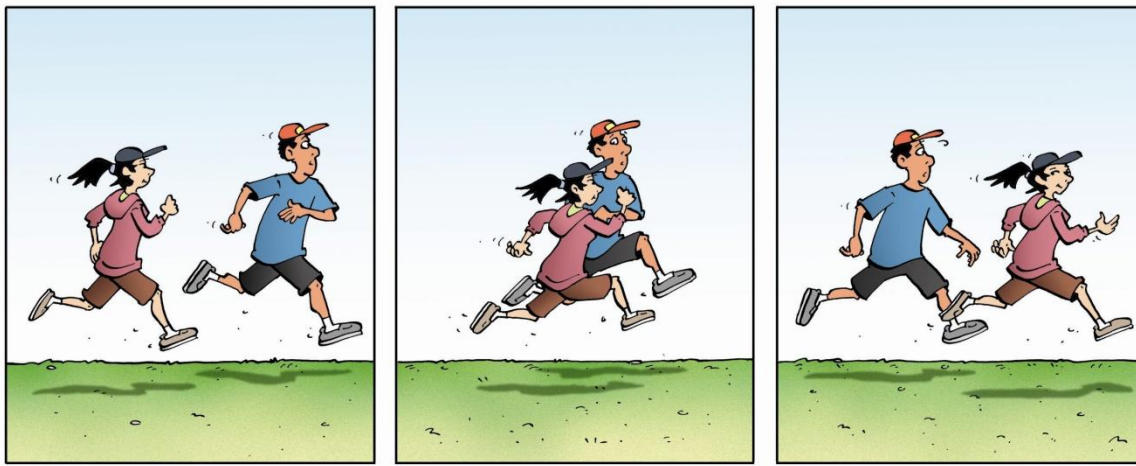
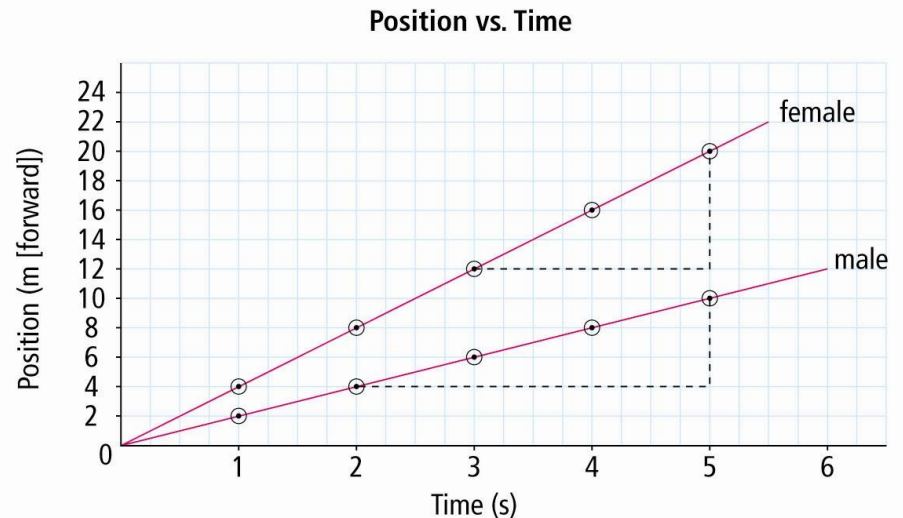


Figure 8.18A A motion diagram of two joggers. The female jogger is travelling faster than the male jogger.

Which jogger's motion has a greater slope?

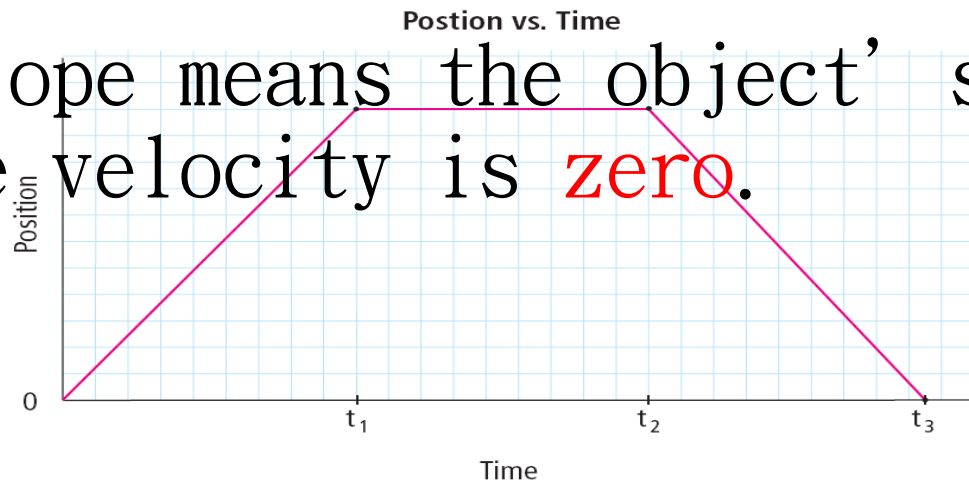
Which jogger is moving faster?

•Change in position divided by time is velocity, so the slope of a position-time graph is the average velocity!



On a position-time graph, if forward is given a positive direction:

- A positive slope means that the object's average velocity is **forward**.
- A negative slope means that the object's average velocity is **backward**.
- Zero slope means the object's average velocity is **zero**.



# CALCULATING AVERAGE VELOCITY

The relationship between average velocity, displacement, and time is given by:

$$\vec{v}_{av} = \frac{\Delta \vec{d}}{\Delta t}$$



Use the above equation to answer the following questions.

1. What is the average velocity of a dog that takes 4.0 s to run forward 14 m?

$$v = 14\text{m}/4.0\text{s} = 3.5\text{m/s}$$

2. A boat travels 280 m east in a time of 120 s. What is the boat's average velocity?

$$v = 280\text{m}/120\text{s} = 2.3\text{m/s}$$





# CALCULATING DISPLACEMENT

The relationship between displacement, average velocity, and time is given by:

$$\Delta \vec{d} = (\vec{v}_{av})(\Delta t)$$



Use the above equation to answer the following questions.

1. What is the displacement of a bicycle that travels 8.0 m/s [N] for 15 s?

$$d = 8.0 \times 15 = 120\text{m [N]}$$

2. A person, originally at the starting line, runs west at 6.5 m/s. What is the runner's displacement after 12 s?

$$d = 6.5 \times 12 = 78\text{m [W]}$$



# CALCULATING TIME

The relationship between time, average velocity, and displacement is given by:

$$\Delta t = \frac{\Delta \vec{d}}{\vec{v}_{av}}$$

Use the above equation to answer the following questions.

1. How long would it take a cat walking north at 0.80 m/s to travel 12 m north?

$$t = 12/0.80 = 15s$$



2. A car is driving forward at 15 m/s. How long would it take this car to pass through an intersection that is 11 m long?

$$t = 11/15 = 0.73s$$



## CONVERTING BETWEEN M/S AND KM/H

- To convert from km/h to m/s:
  - Change km to m: 1 km = 1000 m
  - Change h to s: 1 h = 3600 s
- Multiply by 1000 and divide by 3600  
or
- Divide the speed in km/h by 3.6 to obtain the speed in m/s.

For example, convert 75 km/h to m/s.

$$\frac{75 \text{ km}}{1 \text{ h}} \times \left( \frac{1000 \text{ m}}{1 \text{ km}} \right) \times \left( \frac{1 \text{ h}}{3600 \text{ s}} \right) = 21 \text{ m/s}$$



Speed zone limits are stated in kilometres per hour (km/h).

# CONVERTING BETWEEN M/S AND KM/H

Try the following unit conversion problems.

1. Convert 95 km/h to m/s.  
(26 m/s)



2. A truck's displacement is 45 km north after driving for 1.3 h. What was the truck's average velocity in km/h and m/s?  
(35 km/h [N], 9.6 m/s [N])
3. What is the displacement of an airplane flying 480 km/h [E] during a 5.0 min time interval?  
(40 km [E] or 40, 000 m [E])